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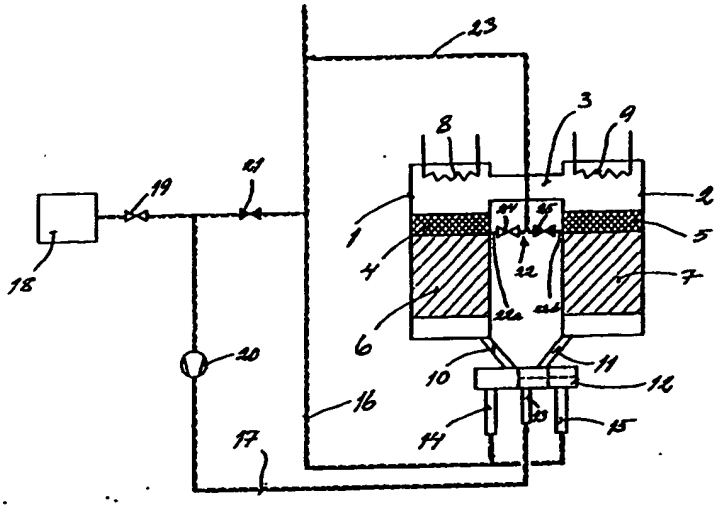
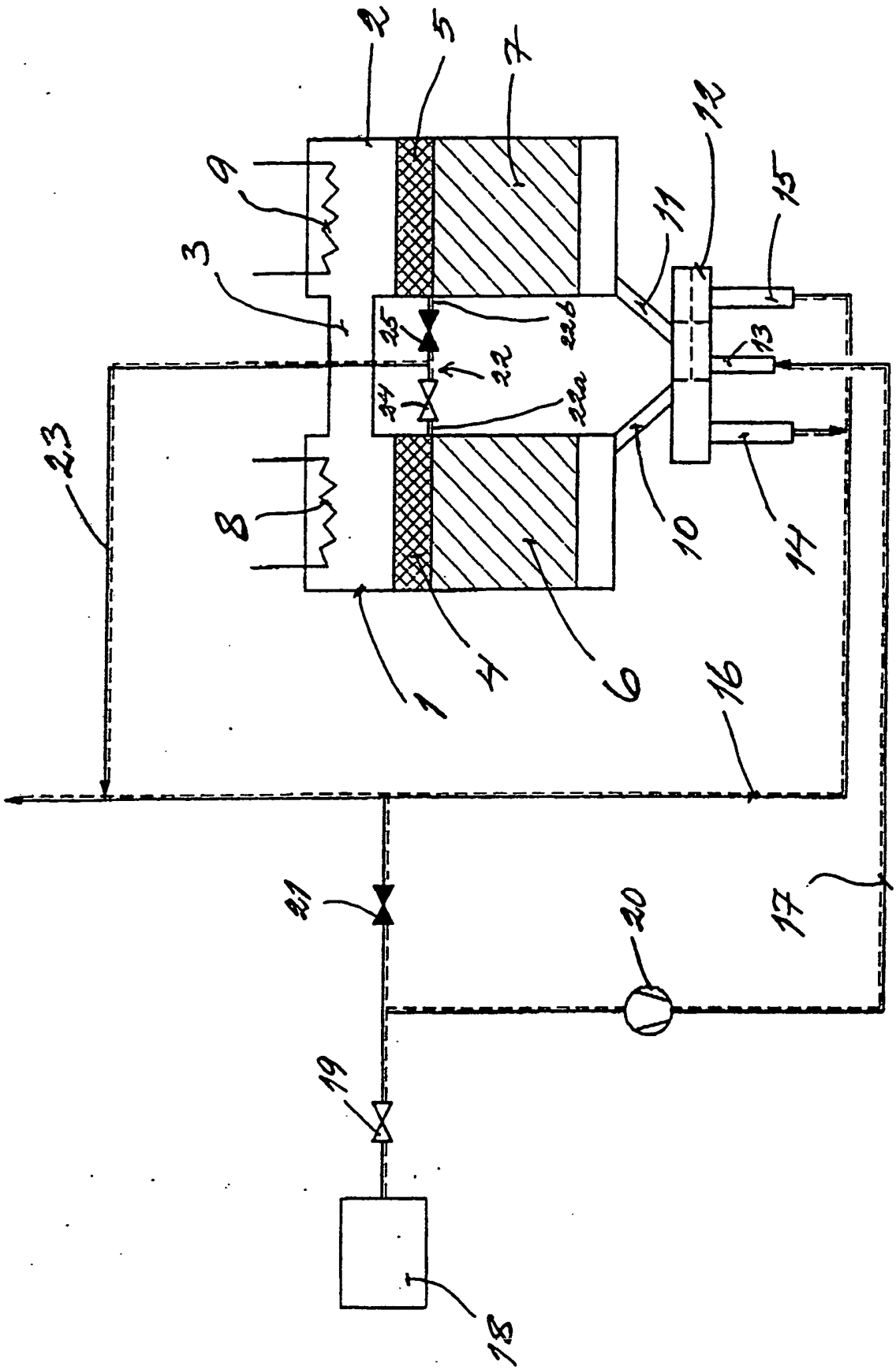


(57) Abstract

This invention relates to a method of purifying gases which are polluted by hydrocarbons and the like in an apparatus comprising two reactors, each reactor comprising a catalyst bed and a ceramic bed. According to the invention the method is characterized by the combination of the following moments: the gas that shall be purified is forced to stream alternately through a passage comprising the first reactor (1) and the second reactor (2) (clockwise streaming) and the second reactor (2) and the first reactor (i), respectiveiy (counterciockwise streaming), the purification of the gas is made by the fact that the hydrocarbons in the gas are oxidized to carbon dioxide and water in the catalysts (5, 6); the temperature of the gas streaming through the reactors (1, 2) is measured and when the temperature exceeds a certain level, a portion of the gas is taken out from the apparatus during the passage of the catalyst bed (5) of the second reactor (2) if the gas streams in a clockwise direction, whereas a portion of the gas is taken out from the apparatus during the passage of the catalyst bed (4) of the first reactor (1), if the gas streams in a counterclockwise direction. The invention also relates to an apparatus which is useable for carrying out the method.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A purifying apparatus

This invention relates to a method of purifying gases which are polluted by hydrocarbons and the like. The invention also relates to an apparatus which is usable for carrying out the method.

Authorities and the public have lately strongly increased the demands for a reduction of outlets of substances polluting the environment. Such substances can be hydrocarbons in solvents which are admixed to the ventilation air from an industrial plant.

There is today in the market an apparatus for purifying gases, for instance ventilation air having an admixture of hydrocarbons, the purification being made by catalytic combustion so that the hydrocarbons damaging for the environment are transformed to carbon dioxide and water. This apparatus comprises two reactors, each of which having a catalyst bed and a ceramic bed. The combustion reaction is exothermic, i.e. it emits heat. If the concentration of pollutions, i.e. in this case the content of hydrocarbons, is high enough, the combustion process becomes self-supporting, which means that no external energy needs to be supplied.

Heat emitted during the combustion reaction increases as the content of pollutions increases in the gas that shall be purified. This means that the temperature in the purification apparatus can be so high that the material is damaged. Owing to that the apparatus known in the market has limitations regarding the possibility to manage purification of gases having high contents of pollutions.

According to known technique there has been an attempt to solve this problem by making possible to take out gas to atmosphere at an area between the two reactors (see for instance EP-337 143). In order that this shall be acceptable from an environmental point of view, however, such a channel going out to the atmosphere has to be provided with a separate catalyst. This solution is of course both complicated and expensive.

This invention intends to offer a solution of the problem of purifying gases having high contents of pollutions, which solution is uncomplicated, relatively spoken, and attractive from an expenditural point of view. This has been made possible by a method of the kind mentioned by way of introduction, which is characterized by the moments mentioned in the claims.

A preferred embodiment of an apparatus according to the invention, useable for carrying out the method shall be described more closely below with reference to the accompanying drawing.

Referring to the drawing is shown there the new apparatus. This one comprises two reactors 1, 2 which are placed at a distance from each other and are preferably cylindrical.

The two reactors 1, 2, which are preferably vertically arranged, are at their upper portions connected by a pipe means 3. Each reactor 1, 2 has a catalyst bed 4, 5 and a ceramic bed 6, 7. The catalyst beds are intended to function as purification means for the gas, whereas the ceramic beds are intended to function as heat storage means. Furthermore, each catalyst bed 4, 5 is placed on the top of the ceramic bed 6, 7. An electric heater 8, 9 is arranged in the upper portion of each reactor 1, 2. External, electric energy by these two electric heaters can be supplied to the gas which is intended to stream through the reactors. Of course, it is possible to use a gas burner instead of electric heaters for heating the gas. The lower portion of each reactor 1, 2 is connected by a pipe means 10, 11 with an exchange valve 12, by means of which it is possible to control the instreaming gas flow so that it first passes the first reactor 1 and then the second one 2, alternately, first the second reactor 2 and then the first one 1. Due to that fact the ceramic beds 6, 7 alternately function as heat absorbers and heat emitters.

The exchange valve 12 has an entrance 13 for polluted gas and two exits 14, 15 for purified gas. The exchange valve 12, however, is so designed that when the one exit 14 is open, is the other exit 15 closed and vice versa. The two exits 14, 15 are connected to one and the same conduit 16 which leads the purified gas out to the atmosphere.

The entrance 13 of the exchange valve 12 is connected with a conduit 17 which is intended to lead the polluted gas from an emission source 18 via a shut-off valve 19 and a fan means 20 to the exchange valve 12 and further into the reactors 1, 2. Between the conduits 16, 17 there is a arranged a bypass-valve 21.

The apparatus further has a conduit 22 connecting the two reactors 1, 2 with each other. This conduit 22 is connected to each reactor 1, 2 approximately at the transition area between the catalyst bed 4, 5 and the ceramic bed 6, 7. The conduit 22 is connected with the conduit 16 to the atmosphere by a further connection conduit 23. Due to that fact there is created a conduit portion 22a connecting the one reactor 1 with the connection conduit 23 to the atmosphere and a conduit portion 22b connecting the other reactor 2 with the connection conduit 23. In each of these two conduit portions 22a, b is a shut-off valve 24, 25 arranged. These valves are so arranged that when one 24 is open, is the other one 25 closed and vice versa. According to the preferred embodiment shown in the drawing the conduit 22 is connected to respective reactor in the border layer between the catalyst bed and the ceramic bed. Due to that fact an optimum purification is achieved also of the gas which is taken out form the apparatus via the conduits 22, 23.

The apparatus functions in the following way:

When starting the system the valve 19 close to the emission source 18 is closed at the same time as the bypass-valve 21 is kept open. The fan means 20 transports air via the conduit 17, the exchange valve 12 and the conduit 11 into the second reactor 2 (with the position the exchange valve 12 has in the drawing). The air passes the electric heaters 9 and 8 where it is heated and further through the catalyst bed 4 and the ceramic bed 6 of the first reactor 1.

In the ceramic bed 6 the heat of the air, which was absorbed from the electric heaters, is accumulated. After a counter-clockwise streaming in the apparatus during a certain time, the position of the exchange 12 is changed so that the air is allowed to stream in a clockwise direction, i.e. the air is allowed to pass the apparatus via the first reactor 1 and the second reactor 2. The air absorbs the accumulated heat amount in the first ceramic bed 6 which at the same time is cooled. Furthermore, the air gets a heat addition from the electric heaters. During the passage through the second reactor 2, the heat amount of the streaming air is emitted to the second ceramic bed 7 which is accordingly heated. Thus, the ceramic beds 6, 7 alternately function as heat absorbers and heat emitters.

As the alternate streaming continues, the temperature of the air increases. At a certain temperature the valve 19 close to the emission source is opened at the same time as the by pass-valve 21 is closed. This fact has the consequence that polluted gas from the emission source 18 is conducted into the purification apparatus and is allowed to stream through the purification apparatus comprising the reactors 1, 2. In this phase the streaming of the gas is made alternately in a counter-clockwise and a clockwise direction.

The catalytic combustion process starts at a temperature of about 300°C. In that connection hydrocarbons of the polluted gas are oxidized to carbon dioxide and water which can be let out to the atmosphere.

As has been mentioned previously, the combustion process is exothermic, i.e. energy is made free during the oxidation to carbon dioxide and water. This energy amount made free can be sufficient for maintaining a stable temperature in the apparatus. However, the energy amount made free increases with an increased degree of pollution of the gas, i.e. with an increased content of hydrocarbons in the gas. This fact can lead to severe material problems in the apparatus if the degree of pollution is high in the gas that shall be purified.

According to the invention the problem is solved by the fact that heat is deaerated via the conduit 22a alternatively 22b and the conduit 23 out to the atmosphere. This is made in that way that the temperature of the gas being purified is recognized in the upper portion of the apparatus. If the temperature exceeds a certain value, let us say 500°C, the valve 24

is opened during a counter-clockwise streaming (the valve 25 is closed), while the valve 25 is opened during a clockwise streaming (the valve 24 is closed). Due to that fact hot gas can stream out via the conduits 24a, b and 23 so that the temperature in the apparatus is kept on an acceptable level. Thanks to the fact that the conduits 22a, b have such a connection to the two reactors as has been mentioned previously, the gas is allowed to pass also the catalyst number 2 in the circulation system, before the gas is let out to the atmosphere via the conduits 22a, b and 23. Due to that fact also the deaerated gas becomes effectively purified.

Thus, this new apparatus functions effectively when purifying gases which are strongly polluted by hydrocarbons. The apparatus is also very suitable to be used when cleaning gases in which the content of hydrocarbons strongly varies.

The invention has been tested in several different plants and it has appeared that it functions very effectively. During one of the tests a report was made of the measurement of the degree of purification during purification of hydrocarbons (propane). In that connection the following measuring method was used:

FID-ANALYSATOR JUM 3-300, calibrated to propane and nitrogene. The following result was received:

Measuring point	Measured airflow	Measuring period	Average content of pollutions	Degree of purification	Temperature area
Intake air	14.600 Nm^3/h	13,43 → 16,09	1619 ppm *)		
Exhaust air	14.600 Nm^3/h	13,43 → 16,09	76,5 ppm *)	95,3%	
Deaeration ventilation	4.500 Nm^3/h	13,43 → 16,09	76,5 ppm *)		500-450°C

*) 1619 ppm corresponds to 3,52 g Nm^3.

76,5 ppm corresponds to 0,166 g/Nm^3.

The maximum values of the degree of polution were 3.500 ppm (7,6 g/Nm^3).

As appears from the table 4.500 Nm^3/h were deaerated. This corresponds to a heating effect of 750 kW, which accordingly could be utilized for heating purposes.

As has been mentioned previously the energy amount made free increases with an increased degree of pollution in the gas. The deaerated heat energy amount, based on a heating effect of 750 kW according to the test, would accordingly correspond to an extra degree of pollution of approximately 5 g/Nm^3. This means that the working area for a plant provided with the new invention can be enlarged from a degree of pollution of about 3 g/Nm^3, which is valid for purification in conventional plants, to a degree of pollution of about 8 g/Nm^3 without any deterioration of the degree of purification.

The invention is of course not limited to what has been described but can be modified within the scope of the following claims.

Claims

1. A method of purifying gases which are polluted by hydrocarbons and the like in an apparatus comprising two reactors, each reactor comprising a catalyst bed and a ceramic bed, c h a r a c t e r i z e d by the combination of the following moments:

- The gas that shall be purified is forced to stream alternately through a passage comprising the first reactor (1) and the second reactor (2) (clockwise streaming) and the second reactor (2) and the first reactor (1), respectively (counter-clockwise streaming), the purification of the gas being made by the fact that the hydrocarbons in the gas are oxidized to carbon dioxide and water in the catalysts (4, 5);

- The temperature of the gas streaming through the reactors (1, 2) is measured and when the temperature exceeds a certain level a portion of the gas is taken out from the apparatus during the passage of the catalyst bed (5) of the second reactor (2) if the gas streams in a clockwise direction, whereas a portion of the gas is taken out from the apparatus during the passage of the catalyst bed (4) of the first reactor (1), if the gas streams in a counter-clockwise direction.

2. An apparatus usable for carrying out the method according to claim 1, comprising two reactors (1, 2), which are positioned at a distance from each other and are connected with each other by a pipe means (3), the first reactor (1) comprising a first catalyst bed (4) and av first ceramic bed (6), whereas the second reactor (2) comprises a second catalyst bed (5) and a second ceramic bed (7), and respective catalyst bed (4, 5) being arranged in connection to respective ceramic bed (6, 7), c h a r a c t e r i z e d in that an area at the transition portion between respective catalyst bed (4, 5) and connecting ceramic bed (6, 7) is connected to means (22, 25) which allow a taking out of gas from respective reactor (1, 2) at the area in question for a further transport to the atmosphere.

3. An apparatus according to claim 2, c h a r a c t e r i z e d in that the means (22-25) allowing a connection to the atmosphere comprises a plurality of conduits (22, 23) and two shut-off valves (24, 25), arranged in these ones, the one valve (24) being intended to open or to close the connection between the first reactor (1) and the atmosphere, whereas the second valve (25) is intended to open or to close the connection between the second reactor and the atmosphere, and the one valve (24) being intended to be open when the other valve (25) is closed and vice versa.

4. An apparatus according to claim 3, c h a r a c t e r i z e d in that the means (22-25) allowing a connection to the atmosphere, comprise a first conduit (22) which connects the two reactors (1, 2) with each other, and that this conduit is connected to a second conduit

(23) in such a way that the first conduit (22) is divided into two conduits portions (22a, b), the one conduit portion (22) connecting the first reactor (1) with the second conduit (23), whereas the second conduit portion (22) connects the second reactor (2) with the other conduit (23), and that the first shut-off valve (24) is positioned in the first conduit portion (22a), whereas the second shut-off valve (25) is positioned in the second conduit portion (22b).

5. An apparatus according to claim 4, each reactor (1, 2) having an essentially vertical extension, and respective catalyst bed (4, 5) being placed on the top of connecting ceramic bed (6, 7), c h a r a c t e r i z e d in that the first conduit (22) is connected to respective reactor (1, 2) in the border layer between the catalyst bed (4, 5) and the ceramic bed (6, 7).